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SHIHMEN SEDIMENT PREVENTION DIVERSION TUNNEL PLANNING AND DESIGN

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ABSTRACT: Shihmen reservoir was started in May 1963. The main purposes of Shihmen reservoir are for agriculture, power supply, flood control and tourism. Shihme Asn dam is an earth dam. Its crown height is 133m above mean sea level, with length 360 m, watershed 763.4 km^2, and maximum volume 309 million cms. Turbidity in Shihmen dam was severely affected by typhoons Aere (2004) and Masa (2005). Increased deposition after Aere was 28 million cms. Turbidity at Shihmen Canal Inlet is 3000 NTU (Nephelometry Turbidity Unit). Sediment sluicing strategies for downstream channel are demanded. Therefore, diversionary sediment preventing channel is planned in the upstream of Shihmen reservoir. Finally, turbid flow in tunnel channel is bypassed and diverted its flow down to downstream.

Keywords: Diversion tunnel; NTU; Nephelometry turbidity unit

1. INTRODUCTION

This study focused on the Shihmen Reservoir watershed turbidity from soil and water conservation implements, Shihmen Reservoir watershed analysis and evaluation, Shihmen Reservoir watershed suggested management practices, and future layout. Based on the investigation data for watershed basic environmental information and human utilization, the reasons for storm hazards caused by the typhoon Aere were further analyzed. Appropriate management suggestions for the Shihmen Reservoir watershed are proposed to policy-making authorities. The main reasons of turbidity are stated as follows.

There are 64.45% of landslides caused by typhoon Aere on the Shihmen Reservoir watershed distributed mainly along 200 meters surrounding the roads. Drainage networks are caused by surface runoff; the geological situations in these areas are fragile and vulnerable for erosion. Road constructions are usually assisted by hydraulic structures such as bridge piers and revetments. However, these dams and embankments are easy to accumulate sediments. Better control polices for mountain torrents are implementing ecological engineering methods or permeable structures. In order to adjust the sediment transport, the sediment evacuation practices are very important. Watershed control practices should be carried out by different stages. In the meantime, illegal lumbering and tillage should be prevented.

The Taoyuan County government has positively implemented the soil and water conservation practices for many years. The new landslide sites for the typhoon Aere are only 0.53% of total areas located under the Taoyuan's jurisdiction. The average landslide denudation rate 0.77% was observed at the human utilized areas in the Fuhsing Village. Comparing to other categories, the effects of soil and water conservation practices are fair to good. However, the managing authorities are under the jurisdiction of separate governments. Lacking of rational participation for governments and effective supervision, even more different executive regulations are using for management, the policy-making and practical implementation are facing serious consequences. In order to improve this situation, a general executive committee for reservoir watershed management is required and necessary. This organization can be the administration center to fully implement tasks such as supervision, investigation, enforcement, management, and development. In the regulation levels, how to integrate current diversified regulations to a single and powerful reservoir watershed management regulation can be the major concern in the future. For effectively diminishing turbidity of upstream open channel from watershed, the diversion tunnel is designed as Figure 1. Based on the analyses of four arrangements, the arrangement A2 is chosen and designed for the diversion tunnel channel.

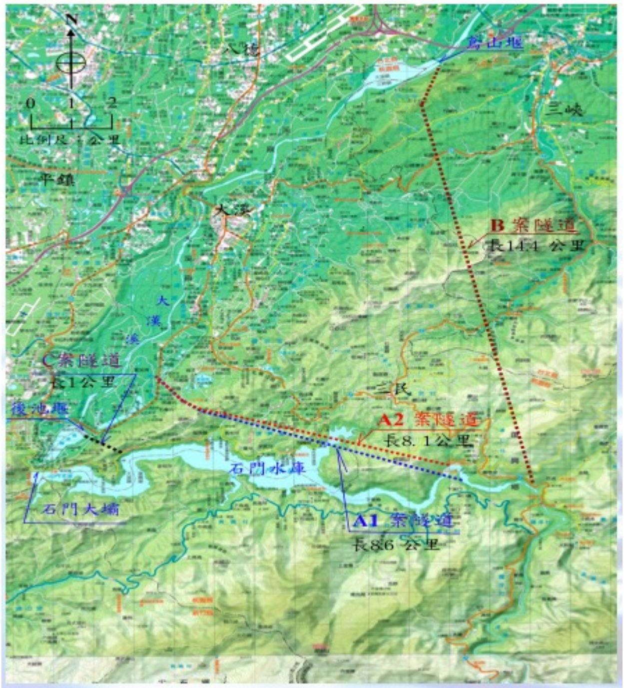

Figure 1. Alternatives of Diversion Tunnel

2. PROBLEMS CONFRONTED IN SHIMEN RESERVOIR

There are two factors in nature: (1) Devastating rainfall and (2) Geological character will cause landslide of mountain slope area. Landslide of mountain slope area will cause then produce turbid raw water. There are four factors by human behaviors: (1) Mountain road excavation, (2) high terrain agriculture development, (3) abandoned mud and sands from road construction, and (4) unsuitable reservoir intakes. Will cause (1) Erosion of surface land area, (2) riverbed siltation and (3) Drifting woods intrading respectively. Then produce (1) Dam area deposited (2) unbalanced water supply and (3) damaged facilities.

3. DIVERSION TUNNEL LAYOUT SELECTION

From Figure1, there are layout A, B, and C. It's based on Inlet Energy. Tunnel energy, upstream siltation and diversion dischange effect. Lay A is the optional solution. However, tunnel length of A2 < A1 and geographic condition of A2 is better than A1. Therefore, finally A2 is the best solution. Its tunnel length is 8,100 m. Inlet engineering arrangement is easier, and upstream siltation line installation is better (than A1). The total construction fee is NT$ 20 billion.

4. LONG-RANGE MEASURES TO MAINTAIN RESERVOIR FUNCTION

Based on Figure 2, especially for long-range measures to maintain reservoir function, it is recommended that: (1) driftwood preventive measure, (2) sedimentation management measure, (3) long-range preventive measure, (4) turbidity preventive measure for generation, and (5) turbidity preventive measure for water supply, should be taken.

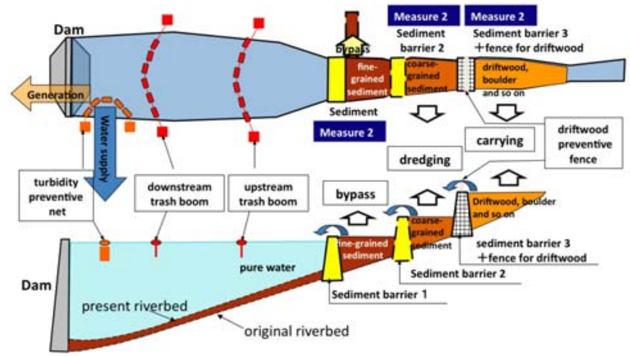

Figure 2. Turbidity Solution of Shihmen Reservoir

Since September 21st, 1999, a sever earthquake attacked central Taiwan and caused ground earth level of Shihmen watershed loosened. During heavy storm, slope area of watershed severely collapsed. Flood carried large volume of mud and driftwood to cause dam facilities damaged, reservoir water became turbid severely, and therefore it made sediment quantity accumulated closely dam area. Consequently, the mentioned above five solutions are very important methods to solve Tuoyuan county area to reduce the turbidity of reservoir water and to protect the civil and industrial use of clear water.

5. CURRENTLY WORK OUT OF WRA (WATER RESOURCES AGENCY)

Since Typhoon Aere attacked Taiwan in 2004, watershed of Shihmen Reservoir carried a large quantity of driftwood into reservoir and caused outlet facilities damaged. Based on the discussion of upper-level staff of MOEA, it is decided that the middle stream of Shihmen Dam were installed two series of trash booms in the year of 2006 and 2007. They are effectively blocking driftwood from upstream of reservoir. Statistically, during typhoon season, they blocked driftwood efficiently totally 43,500 cubic meters

For the upstream sediment preventive measures, low weirs were constructed 123 sets. They were broken 38 sets through Typhoon Aere intruded in the year of 2004. In the dam area,the total accumulated sediment quantities is 32.4 million cubic meters. Due to those low weir functions, recently the sediment accumulation rate of Shihmen Reservoir is slow down. However, Typhoon Aere attacked lead to those low weirs fully occupied sediments, it is necessitated to dredge and clean mechanically or hydraulically.

As for long-range turbidity preventive measure, bypassing the sediment stopped by the sediment barrier 1 through bypass tunnel to the downstream river prevents sediment from flowing into the reservoir. Therefore, it leads to preventing long-range turbidity of the reservoir water.

It is necessary to execute feasibility study about bypass tunnel dimension (diameter, slope, length, etc), assessment of prospective gravel water property, discharge of bypass tunnel, and target gravel range, which is run by flood.

From muddy sand monitoring analyses, reservoir became turbid water during typhoon or storm season. Hence, for escaping extract water by highly condensed turbid sediment effect, the diversion tunnel is suggested to execute rapidly and let the turbid water bypass the reservoir and divert to the downstream. Therefore, measure 2 shows that in front of the low weir, fine grain sediment (turbid water) is bypassed through diversion tunnel down to downstream of the reservoir.

In the upstream of Shihmen Reservoir, it is recommended to build up the diversion tunnel to prevent flooding and discharge turbid polluted sediment through tunnel down to downstream and then the tunnel will carry turbid sediment from upstream to downstream river. Finally, Shihmen Reservoir escapes the turbid sediment and never accumulates sediment in the reservoir. The designed diversion tunnel (8,100 m long) discharge fluid volume around 1,600 cms, then yearly discharge rate could be reached 1.5 million cubic meters. Before construction, it needs to pass Environmental Impact Assessment (EIA). The construction work will be implement in the year of 2012. The designed graphs are from Figure 3 to Figure 14.

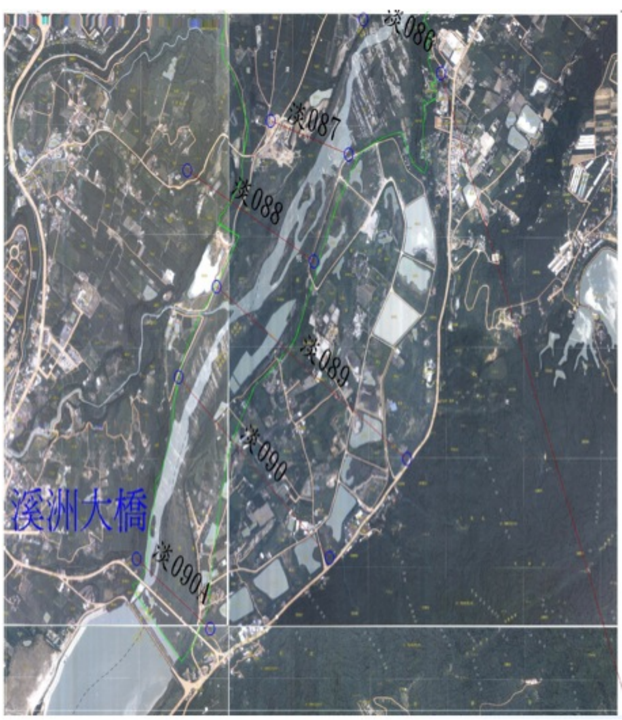

Figure 3. Shihmen Diversion Discharge Tunnel A Outlet Location

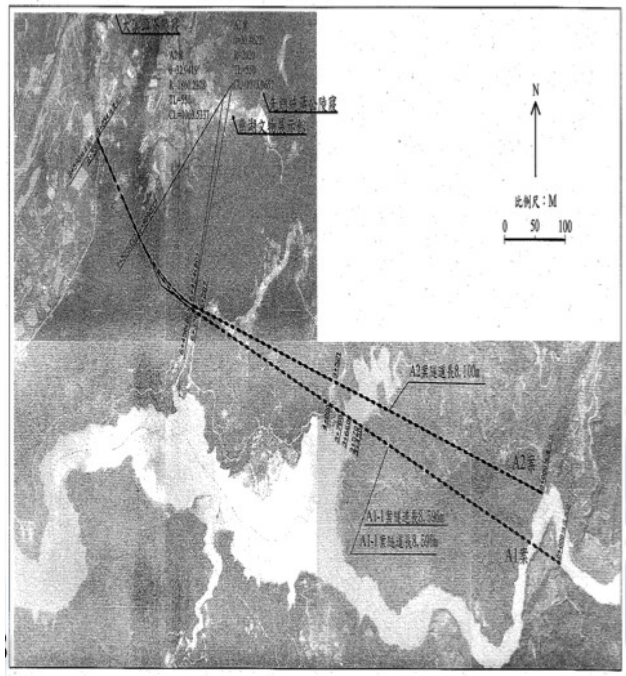

Figure 4. Shihmen Diversion Discharge Tunnel A Plain Arrangement Graph

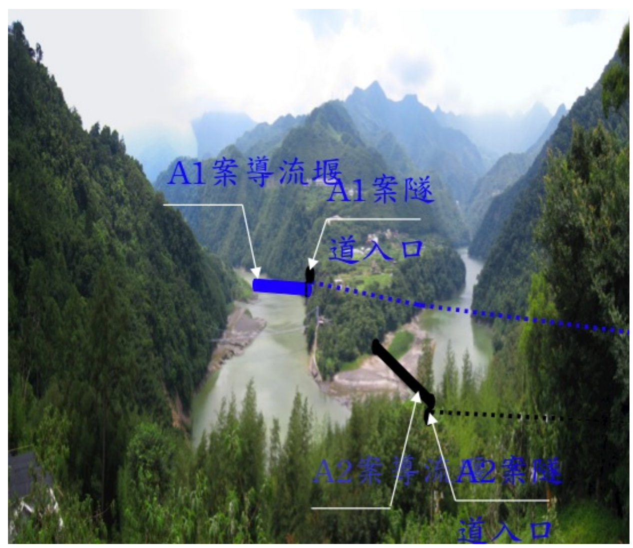

Figure 5. Shihmen Reservoir Diversion Tunnel A Engineering Location Graph (From North to South)

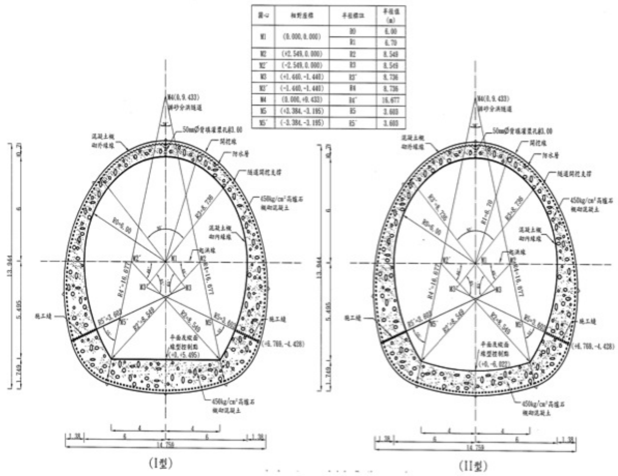

Figure 6. Shihmen Reservoir Diversion Tunnel Standard Design Section

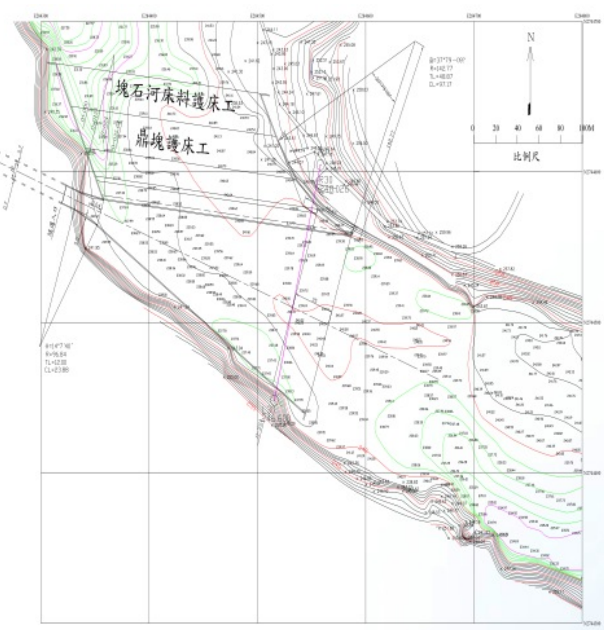

Figure 7. Shihmen Diversion Tunnel A1-1 Inlet Plain Arrangement Graph

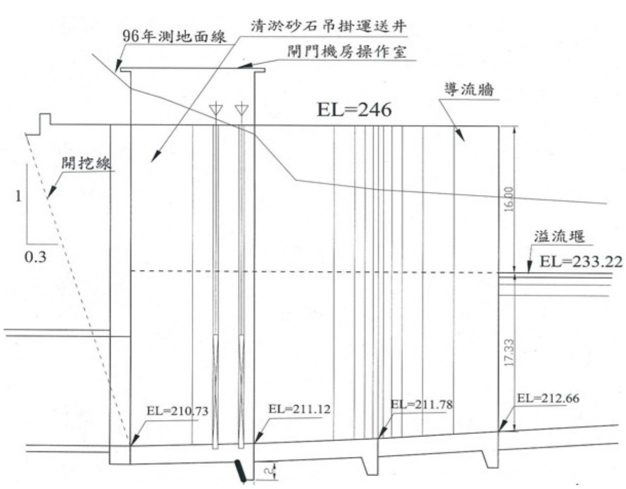

Figure 8. Shihmen Diversion Tunnel A1-1 Inlet Longitudinal Detail Design Graph A

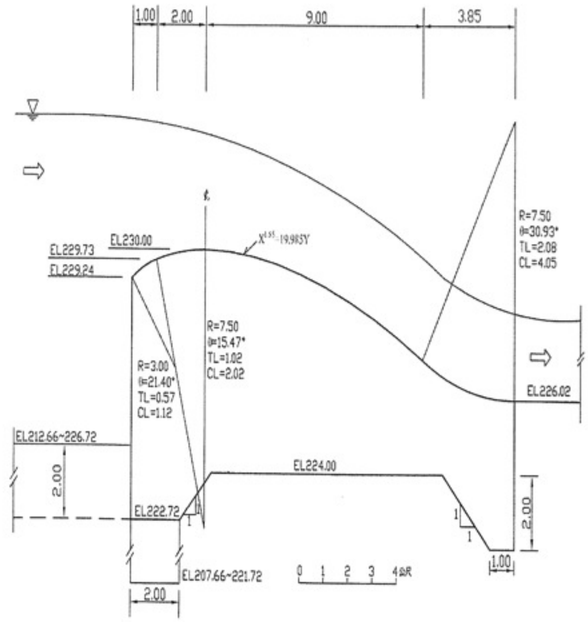

Figure 9. Shihmen Diversion Discharge A1-1 Spillway Standard Design Section

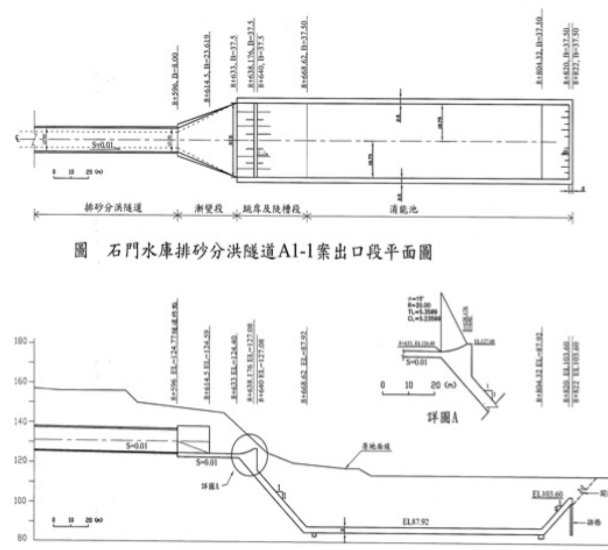

Figure 10. Shihmen Diversion Tunnel A1-1 Outlet Longitudinal Design Section

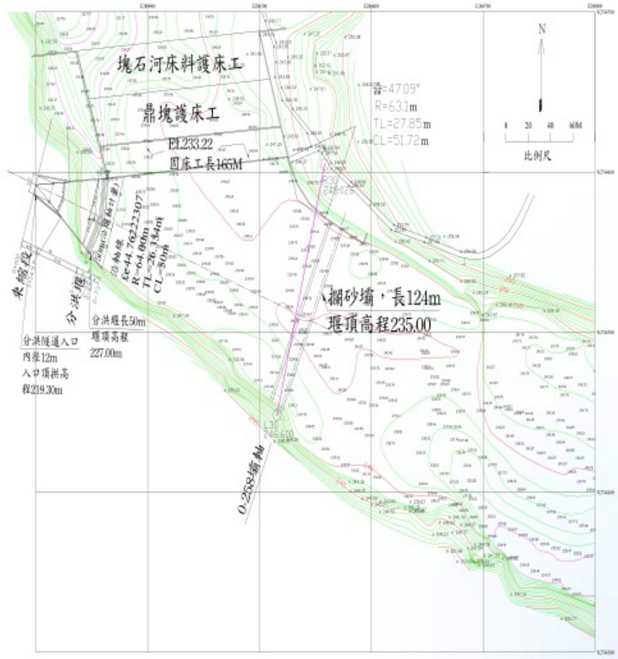

Figure 11. Shihmen Diversion Discharge Tunnel A1-2 Inlet Plain Arrangement

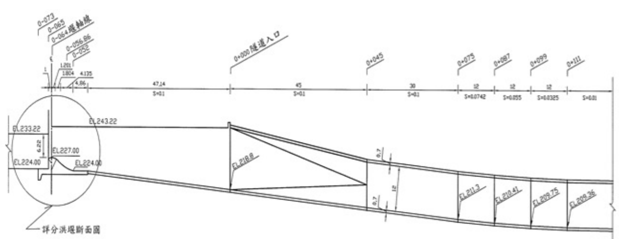

Figure 12. Shihmen Reservoir Diversion Discharge Tunnel A1-2 Inlet Longitudinal Design Section

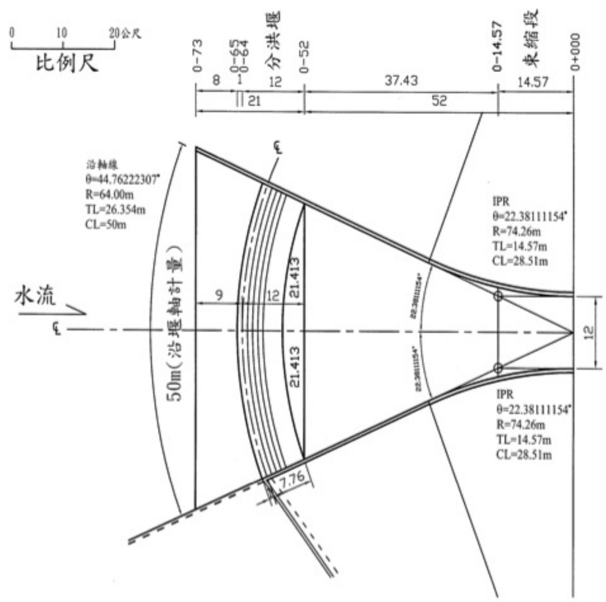

Figure 13. Shihmen Reservoir Diversion Discharge Tunnel A1-2 Inlet Detail Design Section

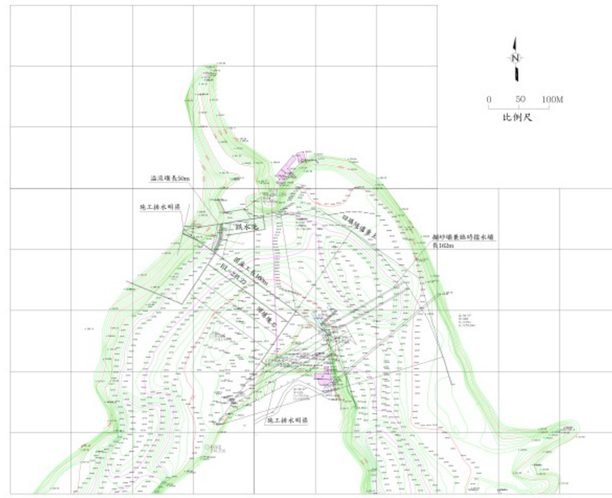

Figure 14. Shihmen Diversion Tunnel Discharge A2 Inlet Plain Arrangement Graph

As for turbidity preventive measure for water supply, it is suggested to set up turbidity preventive net in front of the intake of water supply facilities prevents turbid water from flowing into the intake shown as Figure 2.

6. CONCLUSIONS

Through the Long Range Turbidity Preventive Measure Strategy and Diversion Tunnel Construction, Shih men Reservoir Turbidity will be solved rapidly as expected.

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[2] Lai and Hou, H.S., *Problems and Resolving Strategies for Shihmen Reservoir in Taiwan*, 2006.